The Threat of Transboundary Zoonosis

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ABSTRACT

Global health security, economic stability, and biodiversity conservation are seriously threatened by transboundary zoonotic diseases, which are transmissible diseases that can transfer from animals to humans over international borders. Transboundary zoonoses have become more prevalent in recent years as a result of the intricate interactions between urbanization, the destruction of animal habitats, intensive agriculture, international commerce, and climate change. These diseases have the potential for fast worldwide spread and devastating effects, as shown by well-known examples like avian influenza, Ebola, and COVID-19. An interdisciplinary approach that integrates epidemiology, ecology, veterinary medicine, public health, and socio-political sciences is required to comprehend the dynamics of transboundary zoonoses. In order to prevent and contain epidemics, it is crucial to build early detection and surveillance systems as well as efficient response systems. Additionally, risk communication and community involvement are essential for promoting collaboration between authorities, medical specialists, academics, and the general public. A key area for the spread of zoonotic diseases is the intersection of wild and domestic animals with humans. The management of transboundary zoonoses is intimately related to efforts to conserve biodiversity, highlighting the need of preserving intact ecosystems and reducing human activities that result in habitat degradation and animal trafficking. Given that transboundary zoonoses have the capacity to cross borders and damage many countries at once, international cooperation is essential in combating them. In order to do this, it is necessary to coordinate response activities, share data, resources, and knowledge, as well as facilitate technology transfer and capacity development in underdeveloped areas. This chapter examines the idea of transboundary zoonosis, highlighting its effects on the environment, global collaboration, and the health of people and animals. This chapter attempts to offer insights into managing the complex danger of transboundary zoonoses by looking at case studies and talking about prevention and control techniques.

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1. INTRODUCTION

At the nexus of human, animal, and environmental health, transboundary zoonotic diseases pose a complex and diverse danger. Global health crises and socioeconomic upheavals are brought on by these diseases, which cross geographic borders. Most of the world's population depends on animals for food and other essential resources like transportation and skins. Animal diseases may thus have serious effects, particularly those with high rates of morbidity or, worse, death. A list of transboundary animal diseases (TADs) is kept up to date by the World Organisation for Animal Health (OIE; previously the Office International des Epizooties) and the Food and Agriculture Organization of the United Nations (FAO) (FAO 2021; WHO 2021). To better regulate and reduce detrimental implications, it is necessary to better understand the transmission, dissemination, and pathophysiology of these diseases. The creation of more accurately described in vitro and animal models will be required. Additionally, more research is required to increase the affordability and effectiveness of diagnostics and immunizations. Rapid diagnosis and/or efficient immunization techniques are essential for the management and prevention of these diseases (Torres-Velez et al. 2019). The idea of one health acknowledges how intertwined the health of people, animals, and the environment are. The few TADs that are zoonotic in origin and so contagious for humans are the subject of most of the One Health literature dealing with animal health. Highly virulent avian influenza, anthrax, Rift Valley fever, Ebola, rabies, and Crimean Congo Hemorrhagic Fever are a few examples of these zoonotic infections. Agricultural animals (livestock and poultry) are employed as draft power to transport goods and cultivate crops, which is an overlooked aspect of TADs and One Health. These animals are an essential component of nourishment and the global economy. To more efficiently coordinate preparedness and response across sectors, zoonotic diseases have been prioritized in several low- and middle-income countries worldwide as a result of the recent growing interest in and advocacy for the "One Health Approach" among non-profit organizations, governments, industries and academia (Salyer et al. 2017). One Health Zoonotic Disease Prioritization (OHZDP) tool developed by CDC (Rist et al. 2014) was used in seven countries throughout the world from 2014 to 2016 during the pilot phase of the tool development and testing (Salyer et al. 2017) to analyze themes from one health zoonotic diseases workshops. This chapter explores the idea of transboundary zoonosis, including its causes, effects, and the need for coordinated remedies.

2. DEFINITION AND SCOPE

Transboundary zoonoses are infectious diseases caused by pathogens that can move across borders through the movement of animals, humans, and their products. The term “Zoonoses” is derived from the Greek word “Zoon”, which means animal, and “nosos”, which means disease. According to the World Health Organization (WHO), any disease or infection that is naturally transmissible from vertebrate animals to humans or from humans to animals is classified as a zoonosis (WHO 2020). Among the human pathogens, about 61% are zoonotic in nature (Taylor et al. 2001). Zoonoses is a great public health concern and a direct human health hazard that may even lead to death. Across the globe, the 13 most common zoonoses were most impactful on poor livestock workers in low- and middle-income countries and have caused an estimated 2.4 billion cases of illness and 2.7 million deaths in humans per year in addition to their negative effect on human health (Grace et al. 2012). Most of these diseases affect animal health and decrease livestock production (Grace et al. 2012). The review discusses the significance of these diseases in terms of their potential for rapid spread and the challenges they pose to effective control due to their dynamic nature.

2.1. CLASSIFICATION OF ZOONOSES

Zoonotic diseases are caused by a wide range of pathogens. Based on etiology, zoonoses are classified into bacterial zoonoses (such as anthrax, salmonellosis, tuberculosis, Lyme disease, brucellosis, and plague), viral zoonoses (such as rabies, acquired immune deficiency syndrome- AIDS, Ebola, and avian influenza), parasitic zoonoses (such as trichinosis, toxoplasmosis, trematodiasis, giardiasis, malaria, and echinococcosis), fungal zoonoses (such as ringworm), rickettsial zoonoses (Q-fever), chlamydial zoonoses (psittacosis), mycoplasma zoonoses (Mycoplasma pneumoniae infection), protozoal zoonoses, and diseases caused by acellular non-viral pathogenic agents (such as transmissible spongiform encephalopathies and mad cow disease) (Chomel 2009).

The older classification of zoonoses includes the terms anthropozoonoses, zooanthroponoses, amphixenoses, and euzoonoses (Hubálek et al. 2003). Anthropozoonoses are animal diseases that can be transmitted to humans, such as rabies. Zooanthroponoses refers to those diseases that are transmitted to animals from humans such as tuberculosis in cat and monkey. Amphizoonoses are those diseases that can be transmitted in any direction (from human to animal and from animal to human) such as staphylococcal infection. For some parasitic diseases, humans act as the obligatory host. These parasitic diseases are known as Euzoonoses such as Taenia solium and Taenia saginata infections.

Many zoonotic pathogens can replicate in and survive on dead organic materials like saprophytes and the diseases caused by these agents are known as sapronoses. Examples of sapronoses include fungal diseases (such as coccidioidomycosis, histoplasmosis, and aspergillosis) and bacterial diseases (such as legionellosis) (Somov et al. 1988). The term "saprozoonoses," is defined by the WHO expert committee on zoonoses as pathogens that have a vertebrate host as well as a non-animal reservoir or developmental site (soil, plants, and organic matter) (Schwabe et al. 1964). In many cases, disease transmission may require more than one vertebrate host such as with human taeniasis. These types of zoonoses are known as cyclozoooses. Zoonoses in which both vertebrate and invertebrate hosts are involved are known as metazoonoses such as with arbovirus infection.

Most zoonotic diseases are transmitted to humans from animals. Some reports suggested that animals can also get infected from humans. Such diseases are known as reverse zoonoses. Examples of such pathogens include methicillin-resistant Staphylococcus aureus (MRSA), Campylobacter spp., Salmonella enterica Serovar Typhimurium, influenza A virus, Cryptosporidium parvum, Ascaris lumbricoides, and Giardia duodenalis. In addition, zoonotic diseases caused by pathogens that are occasionally transmitted to animals from humans and then back from animals to humans are referred to as reverse zoonoses.

2.2. ZOONOSES OF DOMESTIC ANIMALS

Domestic animals play a significant role in the transmission of various diseases to humans and in many cases, they work as amplifiers of pathogens emerging from wild animals (Morand et al. 2014). The positive association between domestic animals and humans in influencing pathogen diversity was first hypothesized a long time ago (McNeill 1976). About 60% of human infectious diseases come from vertebrate animals (Taylor et al. 200; Klous et al. 2016). Direct human contact with animals has expanded with the introduction of domestication of different vertebrate animals (Pearce-Duvet et al. 2006). The possible transmission patterns of zoonotic bacteria, viruses, parasites, or fungi are via direct contact, ingestion, inhalation, through the conjunctiva, or biting (Klous et al. 2016).

Cattle, sheep, goats, dogs, cats, horses, pigs, and other domestic animals act as reservoirs of pathogens of domestic zoonoses and can transmit diseases to humans (Samad et al. 2011). Pathogens can be transmitted through direct contact or animal-origin foods. Examples of zoonotic diseases that can be transmitted to humans from domestic animals include anthrax, rabies, tuberculosis, brucellosis, campylobacteriosis, leptospirosis, toxoplasmosis, balantidiasis, ancylostomiasis, toxocariasis, listeriosis, bovine pustular stomatitis, rotavirus infection, and Q fever (Ghasemzadeh et al. 2015; Samad et al. 2011; Bae et al. 2011).

Of these zoonotic diseases transmitted by domestic animals, anthrax caused by Bacillus anthracis poses a significant public health importance. B. anthracis is soil borne bacteria with the capability to produce spores; thus, allowing them to survive in the environment for a very long time. Anthrax can be transmitted to humans through close contact with infected animals (such as cattle and goats) or their products (such as meat, skin, hides, or even bones). (Goel 2015). Human to human transmission exists, but it is very rare. Every year, about 2,000–20,000 humans are affected by anthrax cases globally (Goel 2015). People from India, Bangladesh, Pakistan, the United States, Zimbabwe, Iran, Iraq, South Africa, and Turkey are occasionally affected (Goel 2015). In humans, it can develop malignant pustule, gastroenteritis, and pneumonitis; conversely, sudden death with some systemic lesions can occur in animals. Mortality can be 25–65% in intestinal anthrax; however, it may rise to 100% in pulmonary anthrax (Kamal et al. 2011). Developing countries whose economy usually depends on agriculture are still facing hazardous effects due to anthrax.

Among the bovine zoonoses having serious public health significance, tuberculosis is the most important zoonotic disease. The disease has been a cause of severe economic loss in animal production. It is caused by Mycobacterium bovis, M. tuberculosis, or rarely M. caprae (Torgerson et al. 2010; Bayraktar et al 2011). Mycobacterium is acid-fast soil saprophytes characterized by the presence of mycolic acid in their cell wall. They are also facultative intracellular pathogens. Though bovine tuberculosis has been greatly eliminated from developed countries, other parts of the globe are still facing serious zoonotic effects. Human tuberculosis is the second most common cause of death after AIDS. About 5–10% of all human tuberculosis has been caused by M. bovis (25% of the patients were children). About 53% of all cases showed that the favorable site of tuberculosis is the extra-pulmonary tract (Samad et al. 2011). Most humans are affected with tuberculosis by handling or milking unpasteurized contaminated milk or via aerosols from coughing of infected animals (da et al. 1996). Importantly, M. bovis infection can also happen in the urogenital system of humans and can impact animals through the respiratory secretions from humans acting as reverse zoonoses (Ocepek et al. 2005). However, direct contact of infected animals with humans such as farm workers, veterinarians, abattoir workers, or village people can pose a significant risk.

Brucellosis is one of the most common bacterial zoonotic diseases causing over 500,000 human cases throughout the world every year (Hull et al. 2018). The disease is classified as a forgotten neglected zoonosis as per the WHO (WHO 2015). Among the twelve species of the genus Brucella, Brucella melitensis, B. abortus, B. suis, and B. canis are zoonotic. The common transmission pattern of brucellosis to humans occurs through the consumption of unpasteurized milk or milk products, though the human–human transmission is rare.

Rabies is one of the deadliest zoonotic diseases caused by the rabies virus, which belongs to Rhabdoviridae. Every year about 30,000–70,000 human deaths occur throughout the globe (Krebs et al. 2004). Though dogs are the main carriers of rabies virus, other wild animals including cats and jackals also act as carriers for the transmission of rabies virus. In developing countries, humans are affected by rabies through biting because of the stray dog problem (Tang et al. 2005). In developed countries, bats, foxes, and other wild animals are responsible for the transmission of rabies (Tang et al. 2005).

2.3. ZOONOSES OF PETS, COMPANION ANIMALS, AND BIRDS

About 14–62% of pet owners allow their pets to their bedrooms, which could enhance the emergence of zoonoses (Chomel et al. 2011). Companion and pet animals have increased over the past several decades, but they are also a comprehensive source of disease-producing agents. The increased popularity of pets and companion animals has put human health at risk due to the possible spread of infections. In many houses nowadays, pets of exotic species are kept along with common pets. Therefore, huge people are at risk of acquiring new zoonotic diseases from pets, companion animals, and exotic birds and animals. A variety of infectious diseases (viral, bacterial, parasitic, and fungal) are associated with pets and companion animals (Halsby et al. 2014). The zoonotic diseases frequently associated with pets and companion animal include brucellosis, campylobacteriosis, chlamydiosis, catch scratch fever (Bartonella henselae), ehrlichiosis, giardiasis, hantavirus, hookworms, influenza, rabies, Lyme disease, rocky mountain spotted fever, leptospirosis, monkeypox, pasteurellosis, Q fever, plague, roundworms, salmonellosis, staphylococcosis (MRSA), streptococcosis, toxoplasmosis, and tularemia (Halsby et al. 2014: Jacob et al. 2015).

Transmission of pathogens from these animals occurs through direct or indirect contact. The transmission can take place at home, outside, pet shops, hospitals, or other places. In many cases, transmission also takes place when these animals and birds are brought to shows and competitions (Belchior et al. 2011; Vanrompay et al. 2007). Usually, animal bites or scratches are routes through which humans get the infection such as pasteurellosis and cat scratch disease (Chomel et al. 2014).

2.4. ZOONOSES OF FISH AND AQUATIC ENVIRONMENTS

Many microorganisms with zoonotic significance have been isolated from fish (Boylan et al. 2011). Fish-associated zoonotic pathogens are mainly bacteria. Often, fish unsusceptible to these infections are capable to cause serious sickness in humans. However, these opportunistic fish-borne bacterial infections are limited. Fish can get these pathogens from the aquatic environment where they remain as an indigenous part. In addition, aquatic environments may get contamination from agricultural activities, human and animal excreta, garbage from households, and wild animals. These zoonotic infections may be transmitted to humans through the non-hygienic handling of aquatic animals and/or their products. Consumption of raw or improperly cooked aquatic products may also transmit foodborne infections to humans. Among the zoonotic pathogens isolated from fish, Aeromonas hydrophila, E. coli, Yersinia spp, Brucella spp, Shigella spp, Salmonella spp, Streptococcus iniae, Clostridium botulinum, Klebsiella spp, and Edwardsiella tarda are important (Alworth et al. 2007; Haenan et al. 2013).

Several Vibrio species, at least 12, are often known to be potential for fish-associated zoonoses (Abbot et al. 2007). Among them Vibrio(V.) cholerae, V. parahaemolyticus, V. vulnificus, V. damsela are mostly involved in human illness (Austin et al. 2010; Zhang et al. 2016). Eating contaminated raw or undercooked seafood is the major way through which humans get these Vibrio infections, which can cause serious symptoms such as diarrhea, vomiting, and dehydration (Zereen et al. 2019).

In humans, Mycobacterium tuberculosis causes TB. However, fish are susceptible to non-tuberculous mycobacterial infections. The infections are commonly associated with display aquaria and occasionally with commercial aquaculture systems. They can also be transmitted to humans during aquaculture practice on farms and handling of ornamental fish in aquarium and equipment (Kušar et al. 2017). M.

chelonae, M. marinum, and M. fortuitum are main concerns in aquaculture and fish-related businesses. Among these, M. marinum is a well-known zoonotic pathogen.
Erysipelothrix (E.) rhusiopathiae is a fish-borne pathogen that causes systemic skin diseases in marine mammals (Reidarson et al. 2003). It is a Gram-positive pathogen but no reported disease in fish is caused by this bacterium (Dunn et al. 1990). Similar to other fish-borne pathogens, human and non-human animals are exposed to this bacterium through direct contact with cutaneous wounds on fish (Boylan et al. 2011). E. rhusiopathiae can cause diseases in humans (known as "erysipeloids") and animals (known as "erysipelas") (Gauthier et al. 2015). Fisheries workers are directly vulnerable to the transmission of E. rhusiopathiae during the handling and processing of live and dead fish, which is the reason that the disease is also referred as fish-handler's disease (Reboli and Farrar 1989). The disease is also referred to as "fish rose" due to its symptoms, which include purple or red discoloration of the skin (Reboli and Farrar 1989: Wang et al. 2010).
Lactococcus garvieae is an important fish-borne pathogen affecting a wide range of wild fish species (both marine and freshwater fish), giant prawns from freshwater, and wild marine mammals (Gibello et al. 2016). This bacterium causes severe hyperacute hemorrhagic septicemia (known as lactococcosis) in cultured warm-water fish with high mortality rates and an ultimate ominous impact on the aquaculture industry (Gauthier et al. 2015; Meyburgh et al. 2017; Vendrell et al. 2006).

2.5. ZOONOSES ASSOCIATED WITH FOOD-BORNE PATHOGENS

Food plays a significant role in the transmission of infections, particularly food-borne pathogens, which often cause symptoms of diarrhea. Zoonotic infections are the main cause of many food-borne diseases. Both adult and juvenile populations are susceptible to serious diseases and fatalities from food-borne diseases. Millions of people are affected by mortality, which is often linked to digestive disorders brought on by tainted food and water (Newell et al. 2010). 600 million people, or one in ten people worldwide, are thought to eat tainted food and water each year. 420,000 of those impacted, including 125,000 children, pass away (WHO 2015).
Salmonella spp. (Salmonella enterica serovar Enteritidis), Campylobacter spp, Shiga toxin-producing Escherichia coli (STEC), and hepatitis E virus is typical food-borne zoonotic diseases. Salmonella species and Campylobacter species are responsible for more than 90% of bacteria-related food-borne infections (Thorns et al. 2000).
Verodoxin (Verocytotoxin)-producing E. coli is another name for STEC. Direct contact with infected foods may result in their transmission to people (Treacy et al. 2019). In the 1980s and 1990s, Escherichia coli O157:H7 serotype of STEC was identified as a significant contributor to food-borne zoonotic disease. Humans may suffer from renal failure, bloody diarrhea, and other serious diseases as a result of exposure to STEC strains' toxins (Yara et al. 2020; Mir et al. 2019).
Additionally, many hepatitis viruses, mostly present in animal intestines, including Brucella spp, Listeria spp, Clostridium spp, BSE, Norovirus, Calicivirus, and other Hepatitis viruses, may be spread via contaminated food products. There are several risk factors that contribute to the development of food-borne zoonotic diseases, including the globalization of farm animals and the meat market, eating raw or undercooked wildlife food, the rising prevalence of immunocompromised patients, and inadequate awareness of good hygiene and sanitation.

2.6. EMERGING AND RE-EMERGING ZOONOSES

A newly identified, recently evolving, or previously observed zoonosis that exhibits a rise in incidence or an extension in geographical, host, or vector range is referred to as an emerging zoonosis (WHO

2020). Over the last 70 years, at least 250 zoonoses have been reported as developing and re-emerging zoonotic diseases. With a growing frequency and geographic distribution, numerous diseases have spread quickly over the globe (Grace et al. 2012). Close interaction with animals that serve as reservoirs for newly developing and reemerging zoonotic diseases affects humans (Woolhouse et al. 2005). Among the factors that lead to the emergence of zoonotic diseases are changes in human and animal behavior, habitat, ecology, vector biology, pathogen adaptability, change in farming practices, livestock production systems, food safety, urbanization, deforestation, and climate change (Lindahl et al. 2015). Wildlife may serve as a source or reservoir for viruses that cause newly developing and reemerging zoonotic diseases (Kruse et al. 2004).

Diseases that are developing or re-developing have major effects, not only on global socioeconomic challenges as well as public health (Cutler et al. 2010; Liu et al. 2014). 132 of the 175 novel conditions that have been documented are thought to be emerging zoonotic diseases. According to another study, zoonoses account for around 60.3% of all new diseases. They came from animals in 71.8% of the cases (Jones et al. 2008).

2.7. WILD ANIMALS AND RE-EMERGING ZOONOSES

A variety of infectious diseases are spread and maintained by wild animals because of their complicated relationships with people, domesticated animals, and environmental factors (Thompson et al. 2014). The ecological relationships among the one-health components are being disrupted by factors like as globalization, habitat degradation, climate change, and the extinction of species and biodiversity (Thompson et al. 2013) (Akhter et al. 2020). As a result, zoonotic infections develop and the patterns of their transmission shift. Wild animals may carry diseases that affect both human and animal health, lower agricultural output, and disrupt wildlife (Bengis et al. 2004). Animals in the wild, including mammals, reptiles, birds, fish, and amphibians, serve as a reservoir for zoonotic infections that may spread to people or other animal hosts. It is concerning that wild animals are involved in the epidemiology and spread of zoonotic diseases as shown in the Fig. 1.

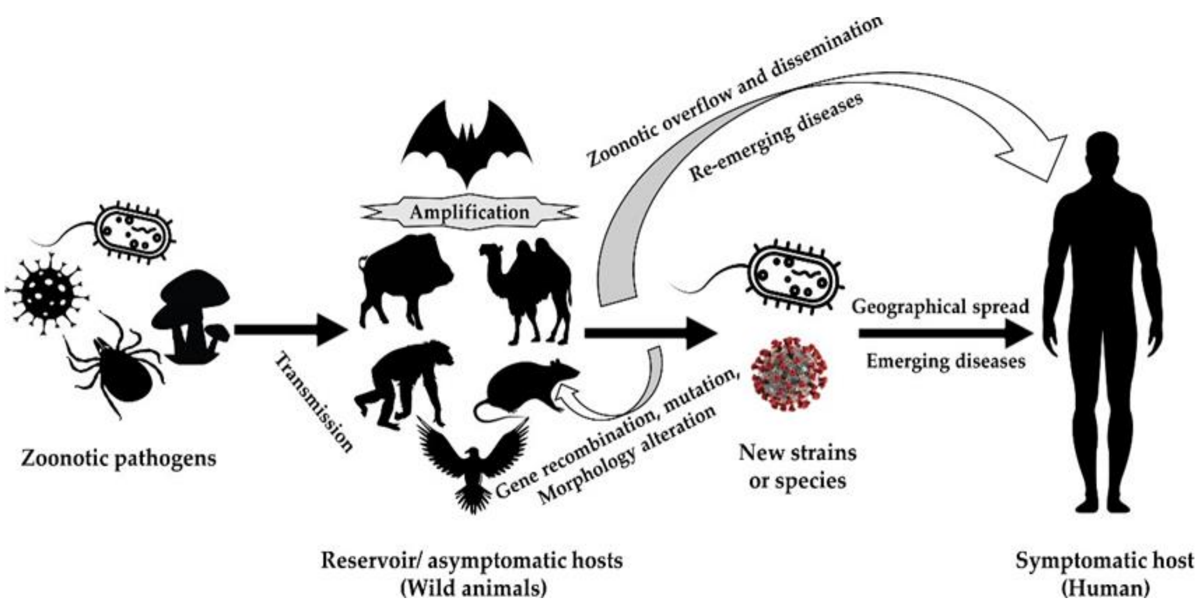

Fig. 1: The involvement of wild animals in the transmission and amplification of etiologicalagents of emerging and re-emerging zoonoses (modified with permission from (Cupertino et al. 2020).

2.8. NEGLECTED ZOONOTIC DISEASES AND IMPLICATIONS

In the developing world, several zoonotic diseases are widespread, which harms the health and standard of living of the underprivileged. Due to their endemic character, neglected zoonoses are more likely to be unreported and to get less financing from funding organizations than emerging and re-emerging zoonoses (Maudlin et al. 2009). The majority of wealthy nations have had success containing and eradicating neglected zoonotic diseases (WHO 2011). Fig. 2 illustrates the key characteristics of neglected zoonoses. Generally speaking, neglected diseases are more prevalent in tropical regions, which is why they are frequently referred to as neglected tropical diseases. Since neglected zoonotic diseases are given less importance in many nations' health systems, they have subtly increased morbidity among rural residents. At the "World Health Assembly" in May 2013, representatives from 32 WHO member nations took several significant decisions to manage 17 neglected zoonotic diseases. Additionally, they put into practice a WHO roadmap for the evaluation of preventative and control measures for those neglected tropical diseases (WHO 2020). Rabies, anthrax, cysticercosis, brucellosis, foodborne trematode infections, leishmaniasis, echinococcosis, and zoonotic sleeping sickness are significant zoonotic diseases. Rabies in Africa and Asia, echinococcosis, and taeniasis (*Taenia solium*) in Asia, Africa, and Latin America, leishmaniasis in Asia and Africa, cysticercosis, and foodborne trematodiasis in Africa are zoonotic diseases that have been neglected (neglected zoonoses) (WHO 2020).

3. CASE STUDIES

To illustrate the diversity and severity of transboundary zoonotic threats, this section examines selected case studies

Avian Influenza (H5N1 and H7N9): The spread of *avian influenza* viruses highlights the impact of migratory birds on the transboundary transmission of zoonoses and underscores the need for surveillance and early detection.

Ebola Virus Disease: The cross-species transmission of the Ebola virus from wildlife to humans exemplifies the complex interplay between ecosystems, human behavior, and disease emergence.

Middle East Respiratory Syndrome Coronavirus (MERS-CoV): This case study emphasizes the role of camels as potential reservoirs and intermediary hosts for zoonotic diseases.

4. PREVENTION AND CONTROL

Effective management of transboundary zoonotic threats requires a multi-pronged approach:

Surveillance and Early Warning: Early detection systems that monitor animal and human health, environmental changes, and cross-border movements are essential for timely responses.

Cross-Sectoral Collaboration: Strengthening partnerships between health, agriculture, environment, and wildlife sectors fosters a comprehensive approach to disease control.

Capacity Building: Enhancing local and national capacities in disease surveillance, diagnosis, and outbreak response is crucial for preventing and mitigating transboundary zoonoses.

4.1. INTERNATIONAL COOPERATION

International institutions must enable cooperative efforts between nations to address the common character of transboundary zoonotic dangers. Every disease management strategy needs a substantial financial investment, which is often not accessible to underdeveloped nations. For successful zoonoses management, the developed nations and international donors must assist the poor nations. One option for funding is to approach donor organizations like the World Health Organization (WHO), the Food and Agriculture Organization of the United Nations (FAO), the World Organization for Animal Health (OIE), the US Agency for International Development (USAID), the US Department of Agriculture (USDA), the European Union (EU), the Department for International Development (DFID), the Biotechnology and Biological Sciences Research Council (BBSRC), and the Danish International Development Agency (DANIDA). Similar to public funding organizations, private funding organizations may also be contacted for funds to develop zoonoses control projects (Gibbs et al. 2014).

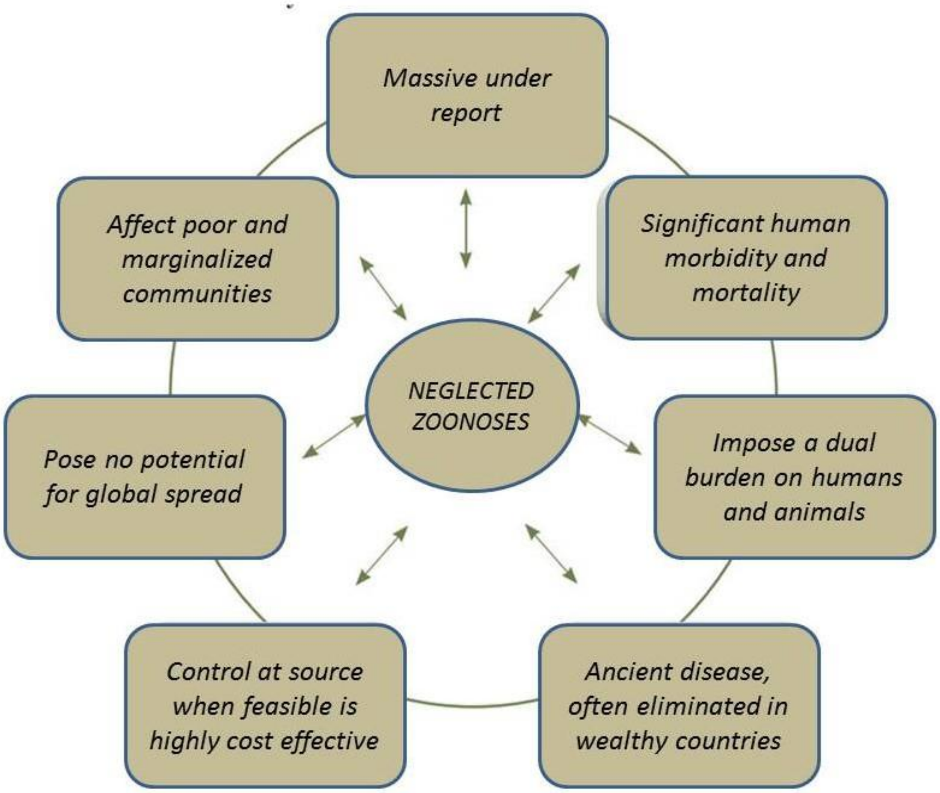

Fig. 2: Basic features of neglected zoonotic diseases (reproduced with permission from (WHO 2011).

The global community faces a major danger to its health from zoonoses. Up to 75% of human diseases are zoonotic, or animal-transmitted, and between 58 and 61 percent of human diseases are communicable (Al-Tayib et al. 2019; Ng et al. 2013). Effective control methods for zoonosis must thus take into account interactions between people, animals, and the environment (Aenishaenslin et al. 2013). For zoonotic diseases to be prevented and controlled, surveillance is essential. It may be used to identify early infection, afflicted people and animals, reservoirs, vectors, and endemic regions including the "hotspots". It assists with the correct management of disease, the adaption of control measures against newly developing and reemerging diseases, and the reduction of human and animal morbidity and death. In order to effectively manage zoonoses, coordinated monitoring strategies at the local, regional, national, and worldwide levels are crucial. Zoonoses (like SARS and HPAI) may quickly travel throughout the world and threaten global societies. All possible zoonoses sources, including rodents, aquatic animals, wild animals, exotic animals and birds, pet and companion animals, need to be monitored. There are several surveillance methods that must be used (Van der Giessen et al. 2010). Effective and functioning surveillance calls for a well-equipped lab, sufficient diagnostic resources, qualified personnel, and funds. The four methods of surveillance listed below may be used to combat zoonoses:

• Monitoring of pathogens to find and classify them.

• Serological surveillance to identify infections in the blood of people or other animals by tracking immune reactions.

• Syndrome surveillance, which uses data analysis based on symptoms to assess the likelihood of certain diseases. The presence of pathogens cannot be determined using this analysis-based monitoring.

• Risk monitoring to find risk variables linked to disease transmission. The prevalence of various diseases and their clinical characteristics cannot be determined using this control technique.

Zoonoses can also be managed using general principles of disease control like treating sick people, immunizing healthy people and animals, limiting animal movement, managing animal populations, and test and cull (anthrax, glanders, and Rift Valley fever). Infected items must be decontaminated in order to lower the risk of contracting new diseases. For instance, brucellosis may be less common if aborted fetuses are properly disposed of. It is important to practice maintaining personal hygiene and using personal protection equipment such gloves, masks, lab coats, helmets, and goggles. To help stop the spread of brucellosis, salmonellosis, and TB, it is necessary to thoroughly disinfect infected objects and spaces when appropriate.

Even though many zoonoses pose a serious risk to public health, particularly in impoverished nations, they are often ignored and go unchecked. Programs to manage zoonoses must take into consideration both human and animal-related issues. When multiple bordering nations are impacted, coordinated zoonoses management strategies must be used. To effectively manage zoonoses, strategies based on one health policy principles must be established, including veterinarians, medical professionals, occupational health physicians, public health operators, conservation officers, and environmental officers (Murphy et al. 2019).

One health-based idea was reinforced among academics and professionals from 21 European and African nations via a research initiative called Integrated Control of Neglected Zoonoses for the control of neglected zoonotic diseases in Africa (Pal et al. 2014).

It is necessary to provide customers with a plentiful supply of safe food in order to manage food-borne zoonoses. Implementing the two major strategies of risk assessment and risk management of food items might help accomplish this. Risk management can be practiced by passing legislation and establishing goals to lower the risk. Risk assessment may be done by gathering and evaluating data, and by offering suggestions based on importance. Foods of animal origin including meat, milk, and eggs must come from healthy animals free of zoonotic viruses. To guarantee the safety of food derived from animals, proper ante- and post-mortem assessment of the animals is essential. For the manufacture of safe food, it is important to provide sanitary conditions at every stage of food processing, including staff members' personal cleanliness. The creation of laws and regulations governing isolation and quarantine, the establishment of robust and efficient disease reporting (notification) systems, farm biosecurity, mass vaccination, testing and slaughter or culling, public awareness campaigns, and health education are additional zoonoses control measures. To better educate the public about zoonoses, mass media, electronic information systems, social networks, text messaging, and other communication channels may all be very helpful.

4.2. ONE HEALTH AND ZOONOSES

International organizations and researchers have characterized the link between humans, animals, and surroundings and embraced a concept known as "One Health Concept" or "One Health Approach" for the prevention and management of infectious diseases such as zoonotic diseases. To effectively address issues with global health, this paradigm was embraced (Bidaisee et al. 2014). To assure good health for animals, people, and our environment, the one health concept promotes cooperation among wildlife biologists, veterinarians, doctors, agriculturists, ecologists, microbiologists, epidemiologists, and biomedical engineers (Aenishaenslin et al. 2013; Dahal et al. 2014; One health. 2020).

One health is directly linked to the prevention and control of zoonoses. According to (Pieracci et al. 2016), the recommendations provided by one health approach to preventing and control zoonoses are Creating a "Zoonotic Disease Unit" to benefit human and animal health organizations; developing a national strategy for the "Zoonotic Disease Unit"; enlisting the leadership of multi-sectoral researchers and pertinent personnel to prioritize zoonotic disease research; adopting veterinary public health policies with collaborators from other nations; and reviewing the zoonotic diseases regularly (2–5 years) to address the emerging and re-emerging diseases.

Infectious disease onset and dissemination in the One Health domains are being driven by global trends. Recommendations Zoonotic diseases pose a significant risk to the public's health. Even though many zoonoses are already under control, there are still many diseases about which we know little, particularly in terms of their distribution, etiology, pathogen, host, vector biology, dynamics, cycle of transmission, predisposing factors, and risk factors. The balance between the host, agent, and environment may be upset at any time as a result of a variety of anthropogenic activities, such as population growth and natural processes that cause the emission of zoonoses. We are unable to anticipate with any degree of accuracy when or how the next zoonoses epidemic will affect the world. To assure or improve our readiness to combat such a pandemic, the following actions need to be ensured or reinforced.

• Active and extensive zoonoses surveillance and monitoring using cutting-edge methods including molecular epidemiology tools and satellite-based remote sensing systems.
• Giving importance to the creation of action teams and zoonoses.
• The availability of diagnostic resources and qualified personnel.
• International, subnational, national, and regional collaboration.
• One health-based strategy that includes veterinary and medical physicians as well as environmental specialists and other experts. • Providing sufficient ongoing and urgent financing.
• Widespread public education campaigns on zoonoses.
• More investigation into the risk factors, pathogen pathogenicity, host biology, and vector biology for disease.
• Monitoring and safeguarding wildlife

Ensure the safe manufacturing of animal-derived food.

Maintain infectious labs' safety to prevent the unintentional spread of zoonotic diseases and bioterrorism.

• Environment protection.
• Public education campaigns at the national and international levels on zoonoses and cleanliness

5. CONCLUSION

Borders and academic fields are irrelevant when it comes to transboundary zoonotic diseases, which necessitates an all-encompassing strategy. The majority of infectious illnesses that affect people are animal-borne. These pathogens not only infect animals with diseases but also pose a major risk to human health. Because of the growing interaction between people and wild animals, it is often the case that changing eating habits, climate change, and ecologically unfavorable human activities impact the establishment and reemergence of many zoonotic diseases. The present COVID-19 epidemic makes clear how catastrophic zoonosis is for the human population. Research concentrating on the one health approach has to be prioritized to uncover crucial intervention stages in the transmission of infections because of the close ties between animals, people, and the environment. Societies may better protect themselves against transboundary zoonotic dangers by comprehending the dynamics of disease formation, the consequences for health, economy, and ecosystems, as well as the techniques for prevention and management. Taking on these difficulties benefits the larger framework of sustainable development and the ideals of One Health in addition to improving the security of global health.

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